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The Effects of Indoor Pollution on Arizona Children

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ABSTRACT. The respiratory health of a large group of Arizona school children who have been exposed to indoor pollutants—tobacco smoke and home cooking fumes—is reported. A significant relationship was found between parental smoking and symptoms of cough, wheeze, and sputum production. Also, children in homes where gas cooking fuel was used had higher rates of cough than children in homes where electricity was used. No differences in pulmonary function or yearly lung growth rates occurred among subjects grouped by exposure to tobacco smoke or cooking fuel. Thus parental smoking and home cooking fuel affected [illegible] respiratory symptom rates in a large group of Arizona school children. Study of pulmonary function, however, revealed no lung function or lung growth effects during 4 yr of study.

INDOOR AIR POLLUTION has been reported to adversely affect human health. While various occupational lung diseases have long been recognized as secondary to indoor pollution, more recent reports have concluded that the general population is also at risk from exposure to indoor pollution.[1-3, 6, 8] Among the forms of indoor pollution which may affect humans are tobacco smoke[2] and cooking fumes.[3] Children, because they are usually nonsmokers, have been studied most frequently. Children of smoking parents have been observed to have more respiratory symptoms and lower lung function than children of nonsmokers.[4, 5] Similarly, children living in homes where gas is used as the cooking fuel have been reported to have more respiratory problems than other children.[6]

The results of studies of indoor pollution, however, have not been consistent. Some investigators have not found that parental smoking or home cooking fuel are important determinants of childrens' respiratory health.[7, 8] At present, these disparate findings are unexplained, but population or methodological differences in studies may be responsible. For example, children living in milder climates may be exposed to lower levels of indoor pollution than children in colder climates. Also, studies to date have been cross-sectional in nature, perhaps producing more variable results than longitudinal studies would.

The author, therefore, chose to conduct a longitudinal study of Arizona children who were exposed to indoor pollutants, findings of which are reported herein.

METHODS AND MATERIALS

The subjects of this study lived in small communities in Arizona: Morenci, San Manuel, and Kingman. Morenci and San Manuel have large copper smelters at the edge of town, but Kingman has no such pollution source. A comparison of respiratory health of the children grouped by exposure to smelter smoke revealed no differences, except in the prevalence of cough.[9]

The communities had similar populations (range 4,000 to 7,312) and elevations (range 3,300 to 4,000 ft). The most important demographic difference among the towns was the percent of the subjects who were Mexican-Americans. Only 5% of the Kingman subjects were Mexican-American, whereas 40% of the San Manuel subjects and 57% of Morenci subjects were Mexican-American. Students, and parents of students, in the third or fourth grade in all

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schools of Morenci and in one school each in San Manuel and Kingman were contacted. The schools in San Manuel and Kingman were selected because of relatively low outmigration rates. In 1978, 379 students were enrolled at the above-mentioned schools.

In 1979, the students whose parents had declined to participate in 1978, and a new cohort of third graders in the same schools, were contacted. By the end of 1979, 676 students from these schools were participating in the study. The participation rate at the end of 1979 was 76.3%, i.e., 676 of the 884 students contacted in 1978 or 1979 were enrolled. According to the percent of students with Spanish surnames on school enrollment lists, study participation was roughly equal in the two ethnic groups.

Enrolled subjects' parents completed questionnaires on enrollment in 1978 or 1979. The questionnaires contained sections concerning the subjects, their mothers, and their fathers. The majority (62.67%) of the parents completed follow-up questionnaires in 1980.

A few subjects completed the follow-up questionnaire only. The first questionnaire contained questions selected from the questionnaire of the Tucson Epidemiologic Study of Obstructive Lung Disease.[10] The follow-up version contained the same questions plus some new questions about home cooking and migration. Based on the parents' responses to specific questions on either the 1978–79 questionnaire or the follow-up one, prevalence rates for various respiratory problems were established. For example, if the response was YES to the question "Does he or she ever have wheezing or whistling in the chest?" the subject under consideration was listed among those with "wheeze."

Another brief questionnaire was administered to the students who were in the sixth grade in 1980. Questions about cigarette smoking and the symptoms of cough and wheeze were asked. No students reported daily cigarette smoking.

Spirometry was performed on each child with either of two rolling dry-seal CPI spirometers. These two instruments were calibrated before each set of tests and were used all 4 yr with approximately one-half of the children using each one each year. No efforts were made to select which children blew into which machine. A nurse-interviewer with extensive experience in pulmonary function testing and the author conducted the testing. Each child was seated, instructed on performing a maximum expiratory maneuver, and given nose clips. Each child then completed at least three maneuvers. Further efforts were obtained from children who did not produce a second best forced vital capacity (FVC) within 5% of their best FVC. The single best forced expiratory volume in one second ($FEV_{1.0}$) was used in the analyses. These values were corrected for barometric pressure and temperature.

Of the 676 children who participated in the study, and who had the sections of the questionnaires completed about their health, 628 had all additional questions completed which asked about their parents' health (Table 1). The discrepancy primarily reflects the number of single-parent families in which questionnaires for a father were not completed. Also, 419 children's parents completed the 1980 questionnaire, which asked about home cooking fuel (Table 2). Of the 676 subjects, 558 had both a satisfactory pulmonary function test result and questionnaire responses to ques-

Table 1.—Prevalence of Various Respiratory Problems in Subjects Grouped by Parental Smoking

	Parent Reports % with					Child Reports % with		
	N	Asthma	Wheeze	Sputum	Cough	*N*	Wheeze	Cough
Both parents smoke	146	7.6	41.1†	12.3†	27.4*	28	21.4	14.3
Anglo-whites	116	7.8	42.2	12.1	24.1			
Mexican-American	30	6.7	36.7	13.3	40.0			
Adjusted rate‡	146	7.5	40.0†	12.0†	27.8*			
One parent smokes	185	5.5	28.0†	11.4†	23.2*	34	11.8	5.9
Anglo-whites	102	7.9	32.0	10.8	25.5			
Mexican-American	83	2.5	22.9	12.0	20.5			
Adjusted rate‡	185	5.2	27.9†	10.9†	23.0*			
Neither parent smokes	297	4.1	27.9†	6.7†	14.1*	62	8.1	6.5
Anglo-whites	168	5.4	31.0	6.5	13.7			
Mexican-American	129	2.3	24.0	7.0	14.7			
Adjusted rate‡	297	4.1	27.6†	6.4†	14.6*			

*The rates of cough are significantly different among comparable subjects ranked by parental smoking ($P < .01$ by trend chi square).
†The rates of these symptoms are different among comparable subjects ranked by parental smoking ($P < .05$ by trend chi square).
‡Rate adjusted for differences in rates of parental smokers among areas of study.

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tions about parental smoking. The results of the testing of these subjects are displayed in Figure 1. A cohort of 120 8-yr-olds, 163 9-yr-olds, and 87 10-yr-olds produced most of the results. These subjects all had at least three annual tests during the 4 yr of the study. Thus, among the test results displayed by age at testing in Table 1, 120/171, 277/365, 371/443, 307/356, and 192/209 of the tests (82.1%) were produced by the cohort with at least three annual tests. Other results are for subjects who had only one or two annual tests.

Of the 676 subjects, 427 had at least one test result and questionnaire response to home cooking and were included in Figure 2. A cohort of 107 8-yr-olds, 134 9-yr-olds, and 79 10-yr-olds produced most of the results in Figure 2.

In Table 3, only the 472 subjects who had (1) a minimum of two consecutive annual tests and (2) appropriate questionnaire responses to parental smoking and in the lower portion of the Table, the 407 subjects who had (1) a minimum of two consecutive annual tests and (2) appropriate questionnaire responses to home cooking are included. A cohort of 119 8-yr-olds, 162 9-yr-olds, and 87 10-yr-olds produced 89.5% of the data for subjects grouped by parental smoking by undergoing annual testing at least three times. A similar, but slightly smaller cohort produced 92% of the data for the subjects grouped by home cooking.

Chi square, trend chi square, and analysis of variance are the statistical methods used in this report.[11]

RESULTS

Table 1 shows the rates of various respiratory symptoms and asthma in the subjects both overall and when grouped by parental smoking and ethnic background. A significant relation between parental smoking and [illegible] production, and cough occurred (P < .05 by trend chi square). Because symptoms occurred more frequently in children from certain areas,[9] the rate of symptoms are also shown with an adjustment for the slight differences in the rates of parental smoking among the areas where children lived. Again, a significant trend occurred.

In an attempt to avoid the possible bias of smoking parents more readily reporting symptoms in their children than nonsmoking parents, a subset of older subjects were asked about cough and wheeze, the results of which are shown in Table 1. While the differences did not reach statistical significance, children of smoking parents reported more symptoms than children of nonsmoking parents.

Table 2 shows the rates of symptoms and asthma among the subjects grouped by home cooking fuel. The rate of cough was higher ($P < .05$ by chi square) in children who lived in homes where gas was used as a cooking fuel. In the Table, an adjustment for differences in home cooking fuel in the different areas of residence was made, as in the analysis of the effects of parental smoking, with little change in the rates.

The results of pulmonary function testing in the children are in Figures 1 and 2 and Table 3. The figures display $FEV_{1.0}$ vs. age at time of testing. Table 3 shows lung growth in the subjects who had at least two annual testings 1 yr apart. Lung growth was calculated by subtracting

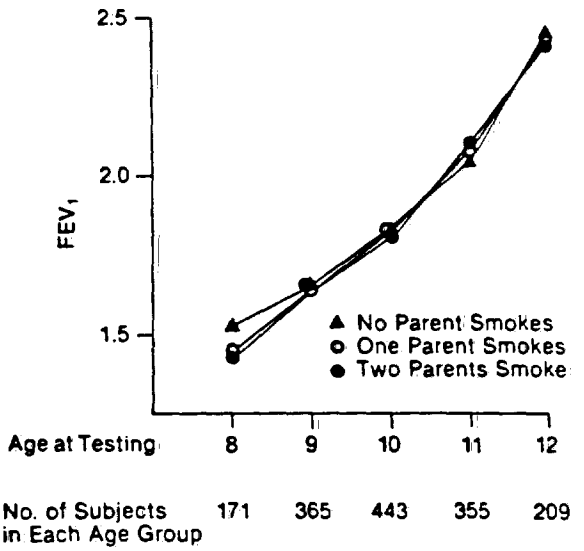

Fig. 1. Lung Function in Subjects Grouped by Parental Smoking.

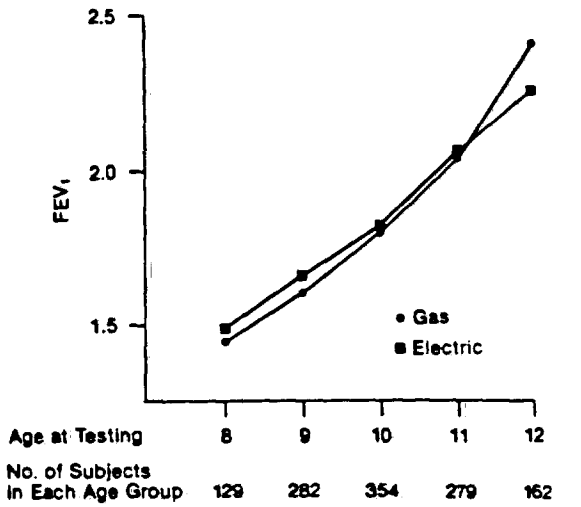

Fig. 2. Lung Function of Subjects Grouped by Home Cooking Fuel.

$FEV_{1.0}/Height^3$ for 1 yr from $FEV_{1.0}/Height^3$ for the year before. The formula is:

$$\text{Lung Growth} = FEV_{1.0_{age+1}} / (Height_{age+1})^3 - FEV_{1.0_{age}} / (Height_{age})^3$$

Parental smoking and home cooking fuel did not consistently affect yearly lung function or lung growth.

DISCUSSION

The present report [illegible] children of smoking parents and children [illegible] fuel had more respiratory [illegible]

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Table 2.—Prevalence of Various Respiratory Problems in Subjects Grouped by Type of Home Cooking Fuel Used

	N	Asthma	Wheeze	Sputum	Cough
Subjects with gas as home cooking fuel	340	4.7	30.6	10.3	20.3*
Adjusted rate†		4.4	31.1	10.1	19.7*
Subjects with electricity as home cooking fuel	79	3.8	29.1	3.8	8.9
Adjusted rate†		3.1	26.7	4.7	10.0

*Rate of cough is significantly higher in subjects with gas home cooking fuel ($P < .05$ by chi square).
†Rate adjusted for differences in rates of gas home cooking fuel among areas of study.

Despite the higher rate of symptoms, however, these subjects had no impaired lung function or lung growth during the 4-yr study. Because of the population studied and the methods used, these result have limited application.

The subjects studied do not represent the general population well. Roughly two-thirds of the children lived in Arizona smelter communities. The author has previously described that the smelter town children, who have been exposed to relatively high levels of sulfur dioxide have a higher prevalence of cough than other children, but comparisons of other symptoms and lung function revealed no differences.[9] Still, smelter town children may be particularly hardy and resistant to the effects of tobacco smoke or gas cooking fumes. When the non-smelter town children were analyzed separately, the results did not differ qualitatively from those when the entire cohort was analyzed. Socioeconomical status differed when the children from different areas were compared, but the status did not affect symptom rates or lung function. Thus, the non-smelter town children and smelter town children appeared to be similarly affected by the variables of parental smoking and home cooking fuel.

The subjects were not randomly selected members of the communities. Approximately one-fourth of the students eligible did not participate, and about 35% of those who did participate contributed only one or two acceptable yearly lung function tests. The subjects who participated for 3-4 yr, then, may not be representative of the general population.

The methods used also limit the application of the study results. No measurements of indoor pollutants were made, therefore, the relation of questionnaire information to actual exposures is unknown. In addition, the questionnaires only asked about parental smoking. While the households with two smoking parents averaged 5.2 persons per household, the same number as households with non-smoking parents, other smokers undetected by the questionnaires may have been present or parents who smoked but did not live with the subject may have been absent. Such persons would have blurred the groupings used in the present analyses.

Despite the above limitations, the study provides evidence that parental smoking and home cooking do not produce serious respiratory problems in Arizona children.

I found, as have others,[4] that children of smoking parents have more respiratory symptoms than other children. To avoid parental reporting bias,[12] all the 1980 sixth graders were asked about respiratory symptoms. While the differences did not reach statistical significance, they again suggested the children of smokers had more symptoms.

Table 3.—Lung Growth of Subjects Expressed as $FEV_{1.0_{age+1}}/(Height_{age+1})^3 - FEV_{1.0_{age}}/(Height_{age})^3$

	N	Age 8-9 yr	N	Age 9-10 yr	N	Age 10-11 yr	N	Age 11-12 yr
Both parents smoke	22	61.84*	62	63.40	73	65.28	47	66.40
One parent smokes	41	68.54	87	65.21	94	64.50	54	68.07
Neither parent smokes	75	64.94	156	65.34	145	64.13	90	67.75
Gas home cooking	94	65.68	204	65.13	211	64.19	132	67.71
Electric home cooking	29	65.80	49	65.31	46	64.93	23	66.16

*The lung growth is significantly different among the subjects 8-9 yr of age ($P < .05$ by ANOVA).

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Also, in agreement with other investigators,[6] I found that children who lived in homes with gas as the cooking fuel coughed more frequently than the other subjects.

The pulmonary function testing showed that neither parental smoking nor gas home cooking fuel adversely affected lung function or yearly lung growth. Tager et al.[5] reported decreased pulmonary function in children of smokers. Others have not found such differences.[7] Similarly, varied results of the effects of gas cooking have been reported.[6,7] To ensure that differences in height did not obscure differences in lung function among the subjects, I also calculated lung growth for each subject who had two or more tests. These results showed that with height cubed taken into consideration, lung growth was not affected by parental smoking or home cooking. Also, when initial lung function was taken into account, by calculating lung growth over the entire period of the study in subjects grouped by initial $FEV_{1.0}$, no differences in the various parental smoking or home cooking groups were found. The results of the present study are good evidence that these factors do not affect the lung function of children living in the southwestern United States. Indoor monitoring, now in progress, may confirm the suspicion that particulate and nitrogen dioxide levels are much lower in the highly ventilated homes of this region than in colder climates.

In conclusion, while parental smoking and home cooking fuel can influence respiratory symptom rates among Arizona children, these variables do not adversely affect lung function or growth.

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